5. Contributions to our Knowledge of the Plankton of the Faeroe Channel.—No. V.[1] Report on a Collection of very young Fishes obtained by Dr. G. H. Fowler in the Faeroe Channel. By Ernest W. L. Holt.

[Received June 18, 1898.]

(Plates XLVI. & XLVII.)

My friend Dr. G. H. Fowler has asked me to name, if possible, the fishes taken in his vertical self-closing tow-net in the Faeroe Channel. My task is rendered the easier by the fact that the greater number of them prove to belong to one species. Individually some of the stages represented could hardly be definitely identified, even generically, but the series is practically complete and has enabled me to add considerably, as I venture to suppose, to our knowledge of the developmental phases of deep-sea forms. Incidentally the species in question, *Scopelus glacialis*, is definitely added to the British fauna, though that is a matter of no great importance. In the case of a pelagic egg and some early larvæ of very elongate form, I have only been able to point out the possible affinities. Two other larvæ, those of *Sebastes norvegicus* and *Gadus æglefinus*, have already received attention at the hands of other observers, but the collection furnishes a stage of *G. æglefinus* that has not hitherto been adequately described. The importance of a really efficient self-closing net, even from the point of view of the mere ichthyologist, can hardly be overrated.

Sebastes norvegicus Ascan. Norway Haddock.

Sebastes marinus, Collett, Norw. N. Atlant. Exped., Fish. 1880, p. 15, pl. i. figs. 3, 4.

Collett refers to this species a number of larvæ or fry which were taken at the surface "in mid-ocean, some nearly 400 kilom. from land," off Beeren Island and Spitzbergen. His examples measured from 9·5 to 19 mm., and two, illustrating the extreme terms of the series, are figured. In the brief description appended the character of the interorbital space and other obvious points of distinction from *Scorpæna dactyloptera* are not mentioned; but we are not entitled to suppose that so careful an observer would have overlooked the possibility of confusion between the two forms.

Dr. Fowler's specimen, 12·5 mm. in length (inclusive), corresponds so closely to Collett's figures (allowing for the difference in dimensions) that it is unnecessary to illustrate it. It appears to be nearly identical in development with a North Atlantic specimen of 12 mm., but the bony ridge of the nape terminates in a single instead of in a double spine. The interorbital space is, in the Faeroe Channel larva, very wide and flat, a character in which

[1] For Part I. see P. Z. S. 1896, p. 991; Part II., 1897, p. 523; Part III., 1897, p. 803; Part IV., *anteà*, p. 540.

the adult *S. norvegicus* differs most strikingly from *S. dactyloptera*. I infer, from the condition of young examples of 40 mm., that the approximation of the eyes manifests itself, in the last-named species, at a very early stage.

The specimen occurred at 60° 2′ N., 5° 49′ W., 100 to 0 fath. Fragments of a little fish, taken at 60° 16′ N., 5° 49′ W., 200 to 100 fath., seem to have belonged to a member of this species, about 20 mm. long.

Collett records examples of 62 to 143 mm. from the bottom at 120 to 150 fathoms. If I have correctly identified Dr. Fowler's larger specimen, it would appear that the younger stage occurs in mid-water as well as at the surface.

Gadus æglefinus Linn. Haddock. (Plate XLVII. fig. 12.)

Gadus æglefinus, G. O. Sars, Rep. Cod Fish. Lofod. (1866, 1867), in Comm. Rep. U.S. Comm. Fish. Fisher. (1877), 1879, p. 590; McIntosh, 15th Rep. Fish Bd. Scot. 1897, p. 196, pl. v.

The collection contains only one Gadoid, viz. a Gadus measuring 8 mm. without the caudal rays and terminal process of the urochord. It is in a good state of preservation, and may be identified with approximate certainty as a young Haddock. The eggs and very early larvæ of this fish are well known [1], and later stages, from 19 mm. upwards, have been well figured by McIntosh. Intermediate conditions have received less attention. Such were known to G. O. Sars, who probably studied them exactly; but, in the only account which I have seen, the Norwegian observer simply remarks that they are distinguishable from corresponding stages of the Cod, *G. morrhua*, by their shorter and stouter shape. McIntosh describes very briefly some specimens of 7 to 8, 11, 12·5 and 19 mm., which he attributes to the Haddock. He supposes that the smaller of the series correspond to the stages taken by Sars.

My figure (Plate XLVII. fig. 12) shows what I suppose to be the essential features of the Faeroe Channel specimen. The proportions and conformation being accurately drawn, need no elaborate description. As in the case of the young Haddock studied by Sars, the form is much more massive than in the Cod. This is seen at once on comparing my drawing with Prince's figure of a Cod, ·33 in., 8·25 mm. *ca.* The total length is about the same, but the larval Cod is much more slender and appears less advanced in general development. The eye is also smaller. Probably whatever postmortem shrinkage may have occurred in one specimen is compensated by a similar condition in the other, and even if the Cod were drawn from a living specimen the difference in conformation is too striking to be entirely explained by a possible distortion of the supposed Haddock. In the latter the pelvic fins are indicated, if at all, by a very slight prominence of the thoracic region. The dorsal and anal fins are indicated by the inflections of the embryonic fin, but only a few of the permanent fin-rays are

[1] *Vide* McIntosh and Prince: Trans. R. S. Edin., xxxv. 1890, p. 822.

in visible process of development. The caudal fin shows features of interest. The extremity of the notochord forms the axis of a lanceolate mass; its extremity is bent up at an obtuse angle, and a considerable part projects freely, being succeeded, to the margin of the fin, by fine embryonic rays. Dorsally occur 12 rays, or 11 and a mass of embryonic rays dividing the last true ray from the urochord. None of these show any distinct basal element. Below the urochord is a roughly trigonal hypural lobe bearing five rays. Anteriorly are three smaller oblong lobes, the most posterior bearing two, the others one ray each. In front occur 6 rays. None of these caudal rays are perfectly formed, the anterior rays, dorsally and ventrally, being but little different from the embryonic rays in front of them. The notochord is still imperfectly segmented, and the myomeres cannot be counted with accuracy. These characters, therefore, like the fin-ray formula, are not available as aids to specific determination. Preserved in formol the specimen naturally possesses no yellow pigment, if any ever were present. The black chromatophores have the distribution shown in my figure on the left side. On the right side there are in addition a few scattered chromatophores. The roof of the peritoneum is seen to be densely black when the specimen is clarified. McIntosh makes no mention of the caudal pigment-bar which is such a prominent feature in the Faeroe Channel Gadus. The chromatophores above the insertion of the pectoral in the latter probably correspond to "a very distinct area of pigment-points behind the pectorals" in Scottish larvæ of 11 mm., and ultimately perhaps to the more posteriorly situate spot of the adult. The development of pigment in Teleostean larvæ is undoubtedly influenced to some extent by conditions of light and, apart from this, is variable in individuals. Probably such differences of coloration as may exist between the Faeroe Channel specimen and those attributed to the Haddock by Professor McIntosh are explicable in this way, but the information afforded, both as to pigment and conformation, in the case of the latter only permits of a conjecture as to their identity. The Scottish examples of 24 mm. and upwards, which are figured and adequately described, are undoubtedly Haddock, and appear to be certainly derivable from such a stage as is exemplified in the larva from the Faeroe Channel.

Dr. Fowler's specimen was taken at 60° 2′ N., 5° 49′ W., at 100 to 0 fathoms. I have myself recorded the capture of spawning Haddock at 154 fath., off the W. coast of Ireland, while Grimsby line-fishermen have told me that they frequently take the species at depths of more than 100 fath. on the wide area which they include in the Faeroe Bank.

Scopelus glacialis Reinh. (Plate XLVI. figs. 1–5; XLVII. figs. 6, 7.)

S. glacialis, Günther, Chall. Rep., Zool. xxii., Deep-Sea Fishes, p. 196; Lütken, Spol. Atlant., Scopel. 1892, p. 30 (250).

Myctophum glaciale, Smitt, Hist. Scand. Fish. ed. 2, ii. p. 941.

? *S. scoticus*, Günther, Chall. Rep., Zool. xxxi., Pelagic Fishes, p. 31.

S. mülleri, Collett, Norweg. N. Atlant. Exped., Zool., Fish. p. 158.

Benthosema mülleri, Goode & Bean, Ocean. Ichth. p. 76.

Young, imperfectly characterized stages of the *Scopelidæ* have been a source of much labour to the various observers who have had occasion to name collections of this group, since it has been quite impossible to determine, in the absence of sufficient material, whether certain differences have a systematic or merely a developmental value. I think I am right in saying that the reproduction is quite unknown, and I can find no description of the early larvæ of any species. With regard to one, the efficiency of Dr. Fowler's vertical net appears to have supplied this want, as I find in his collection what appears to be a nearly complete series of *Scopelus glacialis*.

Though the method has its disadvantages, it appears necessary in the present instance to describe the different stages in the inverse order, commencing with the most advanced. This is a specimen of 58·5 mm., exclusive of the lower jaw and the caudal fin-rays[1]. It has the adult characters peculiar to the species and, except that most of the scales have gone and some of the fin-rays are broken, is in good preservation. No description is necessary except for ontogenetic comparison. The radial formula is D. 13, A. 18. The eye is nearly three times as long as the snout, and is $\frac{5}{11\frac{1}{2}}$ of the length of the head (12 mm.), which is equal to the height of the body at the shoulder and a little more than $\frac{1}{5}$ of the total length. The anal commences nearly opposite the middle of the dorsal. Adequate figures of the adult stage, which is practically exemplified in this specimen, are given by Goode and Bean and by Smitt, but in some copies of the Hist. Scand. Fishes the printing is very imperfect. A clear diagram of the photophores is given by Lütken.

Figures 1 to 7 (Plates XLVI. & XLVII.) represent younger stages in Dr. Fowler's collection. The most advanced of these, fig. 1, measures only 14·5 mm., and has no scales; but the condition of another specimen indicates that the body is covered under natural conditions with dark-coloured scales. The part shaded in my drawing remains, in formol, a bluish grey. The photophores, having the formula of *S. glacialis*, are intact. The radial formula is D. 12 or 13, A. 18. The proportions of the head, eye, and snout are respectively as 31 (= 4 mm.), 10, 7. The eye is thus much smaller, relatively, than in the specimen of 58·5 mm., and the snout longer. Considered in the light of the ordinary ontogenetic changes of these parts in Teleosteans, this condition would appear to prove that the two individuals belong to different species, since as a general rule the eye decreases and the snout increases as development advances. In *Scopelus*, as I shall show, this condition is reversed during some part of the metamorphosis of the larva.

[1] This limitation is implied in all measurements of total length in this paper.

A specimen of 13·5 mm. does not differ greatly from the last. It was evidently fully clad, in life, with dark-coloured scales. The radial formula is D. 11 or 12, A. 15 or 16. I can see no certain indication that any rays have been entirely lost.

A specimen of 12 mm. (fig. 2) has the radial formula D. 14 *ca.*, A. 18. There are no signs of scales. The photophores are incomplete, but such as are present correspond in position to those of fig. 1 and of *S. glacialis*. A low wrinkled ridge of skin occurs along the back from the nape to the first dorsal fin. The proportions of the head, eye, and snout are as 25 (=3·5 mm.), 7, 6. There is thus a further reduction in the eye and increase in the snout as compared with the 14·5 mm. stage; but I think it will be conceded that the two specimens (figs. 1 and 2) are specifically identical. A vertical from the commencement of the anal passes a little behind the front of the dorsal. The base of the adipose is more extended than in the last stage.

Fig. 3 shows a specimen of 11·5 mm. The radial formula is D. 14 *ca.*, A. 18 *ca.*, the rays being rather indistinct in the posterior parts of the fin. The adipose is continued forward by a fold of membrane, beset with numerous embryonic rays, reaching nearly to the base of the dorsal, but its permanent region is indicated by an interneural prominence of the dorsal contour. The proportions of head, eye, and snout are as 25 (=3 mm.), 7, 6, a further reduction of the eye being thus indicated. The specimen is drawn in a rather oblique position. Viewed in exact profile, the top of the eye does not quite reach the cephalic contour. No photophores appear to be fully developed, but one is indicated at the lower extremity of the preoperculum, while some pigment on the mandibles seems to be representative of others. A patch of pigment occurs on the isthmus. Except in the eyes no other external pigment is visible; but internally a black mass in the postero-dorsal part of the abdominal cavity, visible when the specimen is clarified, is probably associated with the air-bladder. The greater part of the abdominal cavity is occupied by a voluminous intestinal tract beset with transverse ridges. The liver is comparatively small, and occurs below the basal part of the pectorals. Posterior to this line the whole cavity, so far as I can see, is occupied by the intestine, which passes by a slight constriction into the pyriform rectum. The mouth is smaller than in the more advanced stages, a condition familiar in the ontogeny of the Salmon.

The most remarkable feature of the larva is a large bladder-like expansion of the skin of the dorsum between the head and the dorsal fin. In the present condition of the specimen it is somewhat collapsed and flattened, its edges projecting from the upper part of the sides. Figs. 3 and 4 show this structure from different points of view, the true dorsal contour being indicated in the profile drawing by a dotted line. It is obviously identical with the wrinkled fold already noted in the 12 mm. stage, which is the degeneration of what is evidently a larval organ. In the specimen

of 11·5 mm., the cavity contains an amorphous plasma, which disappears in a clarifying medium. The larvæ of many Teleosteans, e. g., *Gadus*, *Solea*, are characterized in the vitelligerous condition by an expansion of the anterior part of the dorsal marginal fin, the walls of which are separated and form a sinus of varying size filled by a transparent fluid[1]. The fluid being lighter than the body and yolk, enables the larva to maintain a vertical position, as I have been able to note by watching larvæ of *Gadus luscus*, in which the sinus is well developed. Larvæ not furnished with such a sinus in the vitelligerous stage are seldom vertical in position when at rest, except in the case of large vigorous forms from demersal ova, in which the organs of locomotion are far advanced at the time of hatching. I regard the structure noted in our *Scopelus* larvæ as homologous with the sinus of early Gadoid and other larvæ. It may be, as Ryder supposes, a lymph-space, having nothing in common except contiguity and continuity with the embryonic fin-fold, but I think its function is primarily connected with equilibrium. The most remarkable feature is its persistence, in *Scopelus*, to a comparatively advanced stage of the general development. In *Gadus* &c. it appears after hatching and attains its greatest development at about the end of the vitelligerous period or a little after (as in *G. morrhua*, *teste* Ryder), but disappears, so far as my experience goes, before the permanent median fins commence to appear.

[(*Note added Aug.* 1898.) My friend and teacher, Professor Howes, has called my attention to the possibility of an homology between the dorsal sinus of the young *Scopelus* and a peculiar pad-like process at the anterior end of the dorsal marginal fin of the larva of *Rana alticola*, described by Mr. Boulenger in his Catalogue of the Batrachia. Through the kindness of the last-named observer, I have been able to examine a larva of *R. alticola*. In both cases the structures are continuous with the walls of the marginal fin, but they appear, at present, to have little else in common. In *Rana* the median pad is associated with paired organs of a similar nature, and all three are solid and (*teste* Boulenger) glandular. In *Scopelus* the thin-walled sinus is probably devoid of well-developed glandular matter, but the material is too valuable to be submitted to the arbitry of the microtome.

Although Dr. Fowler's youngest examples of *Scopelus* are too much injured to admit of an exact determination of the extent of the sinus, it appears probable that the latter covers an area sufficiently extended to include the sites of all the glandular pads of *R. alticola*. It is possible that the sinus is an organ of extreme antiquity, of which the isolated pads of *Rana* may be modern derivatives.]

In a specimen of about the same stage of development as that

[1] *Vide* Ryder, Rep. Comm. Fish. U. S. A. for 1885 (1887), p. 496, pl. i. This author does not regard the sinus as part of the larval fin-fold, though its walls are continuous with that of the latter.

last described, the dorsal sinus is collapsed and flattened from side to side, having therefore the appearance of a skinny median ridge. A similar condition appears to have almost certainly furnished the most striking feature of Vaillant's genus *Anomalopterus* (Exp. Sci. Travaill. Talism., p. 160, pl. ix.), which is founded on a specimen of 60 mm. having a kind of adipose fold ("repli, sorte d'adipeuse") occupying the entire length of the back from the head to the dorsal fin. Presuming in an allied family such a developmental increase in the size of the eye as we have seen to occur in *Scopelus*, it appears to me quite possible that *Anomalopterus pinguis* is only a young stage of *Bathytroctes*, the dorsal fold being merely a larval sinus [1].

A younger stage of *Scopelus* is represented in the Faeroe collection by a larva of 8 mm. (as slightly bent), shown in fig. 5. The general conformation appears to clearly associate it with the stage last described. The proportions of head, eye, and snout appear to be as 15, 4, 3, but the posterior boundary of the head is ill-defined and may be farther back than is indicated by my measurements. Relatively to the snout the eye is certainly a little larger than in the last stage. There is a continuous marginal fold, ampullated in the anterior dorsal region, the walls of the sinus extending some little way on to the sides. The dorsal is represented by a prominent interspinous ridge, beset with embryonic rays, but destitute of definite permanent rays. The rest of the dorsal fold bears embryonic rays, the adipose being merely indicated by a prominence of the dorsal contour. Comparing the various stages observed, it would seem that the development of the adipose proceeds on the same lines as the first dorsal and anal, since in the 12 mm. stage (fig. 2) there is an indication of the formation of true rays, which, however, is never consummated. The caudal is in an advanced stage of the familiar metamorphosis, the tip of the urochord projecting very slightly. The anal, more developed than the dorsal, already shows the proximal parts of 16 true rays. Thickened processes of the body-wall external to the origin of the rectum probably represent the developing pelvic fins. The alimentary viscera appear to be in much the same condition as at 11 mm. The anterior part of the abdominal tract is masked by the base of the pectoral and the liver. The rest of the cavity is occupied by a voluminous intestine lined with well-marked annular or spiral ridges. There is little or no black pigment in the peritoneal roof. Externally black pigment is distributed as shown in fig 5. An aggregation near the lower end of the preopercular ridge and another above the middle of the anal fin appear to represent photophores, though no supra-anal photophore is indicated in the more advanced stage of 11 mm. There are about 33 myomeres, of which about 11 or 12

[1] In Vaillant's plate (*loc. cit.*) is a figure of *B. melanocephalus* above that of *A. pinguis*. Allowing for developmental changes on the lines indicated above the two are much alike, but the radial formulæ given in the text are not quite in harmony.

are abdominal. The posterior region of the tail is imperfectly segmented.

Two less advanced larvæ, 6·5 and 4·5 mm. in length, may be taken together. The smallest, fig. 7, has about 31 myomeres, some 14 overlying the alimentary tract. The tail is practically diphycercal. The specimen of 6·5 mm., fig. 6, has the caudal metamorphosis more advanced, and shows an early condition in the development of the anal fin. The alimentary canal is much alike in both, but in the smaller the anterior part is nearly straight. In the larger there is a slight post-œsophageal dilatation, presumably the stomach. This is followed by a (pyloric ?) constriction, distal to which the gut at once expands and is slightly bent towards the left side in front. Posteriorly it tapers to the region of the rectal valve. I cannot detect distinct transverse ridges, but there are some indications of a folding of the lining membrane of the wider anterior part, and I think that this condition may well represent an earlier stage of the voluminous intestinal tract of the more advanced larvæ. A large stellate chromatophore in the abdominal roof, about midway between the supposed pylorus and the anus, apparently overlies a small vesicle, not very clearly outlined. This may represent the air-bladder, and there are indications of its connection by a duct with the anterior part of the alimentary canal. In both specimens the marginal fin-fold is much abraded, but is certainly ampullate in its anterior region. I have not attempted in my drawings to restore it to what may be presumed to be the natural proportions. The teeth are small and not very numerous. The proportions of the head, rather injured in both specimens, are, I think, correctly represented in the drawing[1].

The general conformation, proportions of abdomen, and a sufficient harmony in the number of myomeres seem to reasonably connect these larvæ with the smallest (8 mm.) of the series of *Scopelus glacialis*[2]. It may be objected that in the undoubted *Scopeli* of 11 mm. and upwards, the proportions of snout and eye have been shown to change in a manner inverse to that which obtains in the two smallest larvæ. I think, however, the increase of the eye is a secondary condition of comparatively recent establishment. In the earliest stages I imagine that the eye and snout retain the proportional metamorphosis common in the development of Teleosteans, the snout gradually elongating as development proceeds. This would go on until the attainment of a condition roughly corresponding to that shown in fig. 5. Thereafter the eye commences to increase in size until the adult proportions are attained. Such a condition appears to me more natural than an entire inversal of the metamorphosis whereby the ordinary proportional growth of eye and snout would be reversed from the earliest stage of larval development. In *Arnoglossus laterna* the

[1] The specimen of 6·5 mm. has only one eye, which, whether naturally or otherwise, is oblique in position.

[2] For an intermediate specimen, see note on p. 560.

eye of the male is known to enlarge as a secondary sexual character associated with the development of other structural changes; while according to Grassi [1] the Common Eel (*Anguilla vulgaris*) acquires large eyes in deep water and in the Roman cloacæ. The secondary enlargement of the eye in *Scopelus* is thus not without parallels. *Scopelus* is, I suppose, a form driven from littoral regions to a pelagic and bathybial mode of life, involving an enlargement of the visual apparatus.

Among the pelagic fishes enumerated by Günther in his 'Challenger' monograph (vol. xxxi.) are mentioned a number of small *Scopeli* taken by the 'Triton' in the Faeroe Channel (*loc. cit.* p. 31). While recognizing the close resemblance which these forms bear to *S. glacialis*, the author considers that certain characters deserve specific distinction, and has accordingly described them under the name of *S. scoticus*.

The largest specimen measures 14·5 mm., that is, exactly the same as the *S. glacialis* shown in figure 1. In the dimensions of the eye (naturally considered by Günther, in the absence of any information of the developmental changes of this organ, of importance) the two forms are in practical agreement. The contour of the snout appears to agree with the corresponding stages in Dr. Fowler's collection. The posterior margin of the preoperculum is described as vertical in *S. scoticus*, it is rather oblique in *S. glacialis*. In the characters of the maxilla the two forms agree. The photophore formula is described as identical with that of *S. glacialis*. In *S. scoticus* the origin of the dorsal is nearer to the root of the caudal than to the tip of the snout, and is behind that of the pelvics. In *S. glacialis* of 14·5 mm. the dorsal arises midway between the snout and the caudal; in a specimen of 11 mm. it is a little nearer to the latter; and comparison of the several young stages suggests that in relation to the two points named there is during development a slight variety in the position and perhaps a developmental migration of the fin. It is behind the base of the pelvics even in adults. Younger stages do not differ in any important detail described from those in Dr. Fowler's collection, but specimens of 9 mm. are stated to have the fin-rays perfectly differentiated. In this case the length given appears from the context to include the caudal fin. One specimen of 8 mm. (without caudal) has the rays of the dorsal still undifferentiated. Individual variation in the degree of development at a given size is, however, a common feature in Teleostean ontogeny. The radial formula of *S. scoticus* is stated as D. 10/11, A. 16. That of *S. glacialis* is, according to Goode and Bean, D. 12–14, A. 16–18. In Dr. Fowler's specimens the formula, as we have seen, is D. 12 or 13 to 14 (?), A. 18 and 18 *ca.*, with the exception of one which has only D. 11 or 12, A. 15 or 16. This last specimen is one of the most advanced, in good preservation, and of nearly the same size as another, from which it differs in no detail except the number of fin-rays. I believe that all Dr. Fowler's *Scopeli* can

[1] Q. J. M. S. xxxix. 1896, p. 385.

safely be assigned to *S. glacialis*, and am strongly inclined to consider that *S. scoticus* must be relegated to the synonymy of that species.

In all 15 specimens were obtained on the 'Research.'

Sta.	Depth in fathoms.	Temp. Fahr.	Spec.	Length in mm.
13 *b*.	300–170	° °	1	14·5 ca.
13 *e* [1].	400–270	32–38	2	6·0, 6·5 ca.
			3	11·0 to 14 ca.
13 *g*.	465–335	31–33	1	14·0 ca.
13 *i*.	100–0	48–54	3	4·5, 7·5, 8·0.
15 *c*.	50–30	30–53	1	58·5.
16 *a*.	350–170	31–44	2	12 ca.
			1	larger injured.
19 *a*.	480–350	46–47	1	14·5.
20 *c*.	400–300	31–33	1	13·5.

[1] 13 *e* is suspected of having closed nearer to the surface than the depth here recorded; till all its contents have been identified, it is to be regarded as doubtful.—G. H. F.

Many of these specimens have been more or less injured, but all can be clearly associated with the series which I have described. Günther, Collett, and Goode and Bean agree in regarding *S. glacialis* as a truly bathybial species; but Dr. Fowler's self-closing net furnishes us with the first certain evidence of its vertical distribution. It extends evidently to at least 350 fath., the specimen taken at 480 to 350 fath. being one of the most advanced of the series (fig. 1). This latter specimen enables us to add *S. glacialis* to the British list, the locality lying within Norman's British Area (Ann. Mag. Nat. Hist. 1890, v. p. 345). All the other specimens occurred just outside this area as did also the 'Triton' specimens (*S. scoticus*); the latter were taken in the Faeroe Channel "partly with a surface-net at night, partly with the tow-net, which with a line of 350 and 600 fathoms was worked at various depths" in the Cold Area.

S. glacialis is known from the Northern coasts of Norway, coast of Greenland, Arctic Ocean, and various localities in the American North Atlantic.

[With regard to the vertical distribution of this species,—in the first place, it appears to be essentially a cold-water form. Collett [1] records it as having been taken by the 'Vöringen' once "found floating," and once (three specimens) from 1110 fathoms west of Hammerfest. Previously to this expedition it had been known only from Greenland and Northern Norway. It has since been taken by the 'Blake' [2], at considerable depths only, off the coasts of New England and South Carolina, in the cold undertow which passes under the Gulf Stream and whose upper edge forms the Labrador current and its continuation southward.

[1] Norweg. North Atlantic Exped., Fishes, p. 112.

[2] Goode & Bean: Bull. Mus. Comp. Zool. Harvard, x. p. 222 (1883).

Secondly, like many other cold-water forms, it appears to be eurybathic in high latitudes; the difference in temperature between the superficial and deeper water being comparatively small, and offering no marked thermal barrier to its descent.

Lastly, as regards the Faeroe Channel, it is noticeable that no specimens, larval or adult, were taken at the actual surface in twenty-five hauls; that the smallest specimen of all was captured nearest to the surface, between 100–0 fathoms (Sta. 13 *i.*); that other larvæ were taken in six out of the thirteen deep hauls, and may thus fairly be ranked among Mesoplankton. One (?) adult specimen was taken in a haul which began at 530 fathoms and finished at the surface; this unfortunately gives us no help. Although none of the 'Research' specimens were captured at the surface, still if, as Mr. Holt suggests, Dr. Günther's *Scopelus scoticus* is identical with these larvæ, some larvæ come to the surface at night in the Faeroe Channel.

Though more observations are required for confirmation, still it seems probable that *Scopelus glacialis*, at any rate as regards the Faeroe Channel, falls into the category of animals which have an early epiplanktonic stage, but frequent greater depths when adult (*cf.* p. 578, *infra*). Even in higher latitudes the adult has been most frequently recorded either from considerable depths, or as dead and floating if at the surface.—G. H. F.]

[*Note added Aug.* 1898.—The stages shown in figs. 5 & 6 are connected by an intermediate specimen of 7·5 mm., received too late for description in the text. The proportions of the head, eye, and snout are as in the specimen of 8 mm., but the general form is more slender.—E. W. L. H.]

Imperfectly characterized larva with very elongate abdomen. ? Mallotus villosus Müller. Capelin. (Plate XLVII. figs. 8–11.)

These very elongate larvæ have at first sight much the appearance of young Eels, but closer inspection soon dispels this illusion. They measure respectively 17, 19 (*ca.*), and 24·5 mm., from the snout to the extremity of the notochord. I have figured the most advanced, which on the whole is the most perfect specimen of the series. The others differ little in general conformation, but the smallest has the caudal extremity still practically diphycercal, and the marginal fin terminates, without spatulate expansion, in a sharp lanciform process. The proportionate lengths of the abdominal and caudal regions are shown in Plate XLVII. fig. 8; it will be seen that the abdomen is about twice as long as the tail, the rectum being thus given off at a point far posterior to median. The fore-brain extends but little in front of the eye, which is only of moderate proportions. The considerable bluntly-rounded rostral region is occupied anteriorly by a large olfactory pouch. The angle of the jaws is opposite the front of the eye. The pectorals are small. The pelvics are indicated by a pair of membranous lobes supported anteriorly by

a thickened fleshy rim. They are situate at about the middle of the total length of the larva, and well behind the middle of the abdominal region. The liver occurs as a small pyriform mass shortly behind the clavicle. The alimentary canal, apparently wide and thin-walled in the thoracic region, is soon constricted and thickened. Its ventral wall shows a downward crenulation (about halfway between the clavicle and the pelvics) which may be accidental. At the pelvic region commences a well-marked intestinal tract lined with transverse (annular, perhaps spiral) ridges. The short and rather voluminous rectum leaves the trunk in an oblique direction.

There are 47 abdominal (counted to the origin of the rectum) and 20 caudal myomeres visible: others may probably be seen at a later stage, but the total number will not be much greater than 67. Black pigment is present in a series of ventral spots, seven in number, distributed at regular intervals from the clavicular region backward. These consist for the most part of a single chromatophore on either side of the gut, but at the shoulder there are several, as also at the region of the rectal valve. The pre-peduncular spot of the tail consists of two ventral and one lateral chromatophore. The caudal fin, both as to the embryonic and permanent parts, is rather profusely decorated with small black dots. The eyes are deeply pigmented. The dorsal marginal fin is wide. Anteriorly it is rather imperfect in the specimen figured. In that of about 19 mm. the fin appears to be ampullate anteriorly, and this is probably the natural condition in the others also. There are no signs of the permanent dorsal and anal fins, but embryonic rays occur in the postanal region.

On comparison of the three examples it would appear that the ventral spots become reduced as development advances. Though identical in number those of the largest individual are relatively considerably smaller than those of the younger.

I have noticed elsewhere (p. 565 *infra*) the occurrence in Dr. Fowler's collection of a pelagic egg, which, as far as may be judged from the preserved condition, appears to be practically identical with Raffaele's species No. 7 (Mitth. zool. Stat. Neap. viii. 1888, p. 69). In conformation and in distribution of pigment the form which we are now dealing with bears a striking likeness to the larva of Sp. 7 (*op. cit.* tav. v. fig. 9). The ventral spots are numerically equal, and there is an indication in the Faeroe larva of the large "rhomboidal" supra-cephalic sinus described in Sp. 7. The latter is stated to have 59 or 60 abdominal segments, a condition which indicates that the total number is considerably in excess of that present in the much more advanced Faeroe larva, and so disposes of the possibility of the formula being harmonized in the two forms by a developmental migration of the anus. The marginal fin, though wider in the Faeroe larvæ, terminates, in the youngest example, as in Sp. 7; and in the anterior dorsal region appears to be inflated alike in both forms. But none of the Faeroe larvæ show any trace of the prodigious buccal armature of Sp. 7. The teeth, on the contrary, are quite small.

Sp. 7 is one of a group of ova and larvæ which Raffaele considered to exhibit Murænoid affinities; and Grassi has practically confirmed the correctness of this view in the case of at least one species, No. 10, which he has connected with *Anguilla vulgaris*. Moreover it appears probable that all Murænid larvæ pass through a *Leptocephalus*-stage, losing the buccal armature of what Grassi terms the pre-larval condition. I imagine that it is impossible to connect the Faeroe larvæ with either end of a Leptocephaline metamorphosis; while the condition of the intestine and the caudal fin suggest for them affinities which are not Murænoid. The presence of pelvic fins can hardly be held to prove that they are not Murænoids; at least until Grassi shall have found that such structures never occur as vestigial phenomena in the development of Eels [1].

In 1893 my friend Captain F. Klotz, s.s. 'Dominican,' brought me a number of young fish which he had taken at the surface off the West Horn of Iceland on the 27th July. They range in size from 36 to 57 mm., and in general shape have much the appearance of Sand-eels (*Ammodytes*). The collection is sufficiently serial to show that only one species is present, while the largest appear to associate themselves with the Capelin, *Mallotus villosus*. I have figured the head of the smallest (fig. 9), a specimen of 42·5 mm. (fig. 10), and the largest (fig. 11). The radial formula of the largest appears to be D. 12 (or a few more), A. 21. This specimen has 64 myomeres (perhaps more, as the pectoral region is lacerated) exclusive of the peduncular part of the tail, where a few others are probably present, though not sufficiently defined to be counted. About 49 are abdominal. From the ocular region backward the head is distinctly trigonal in section, the upper surface being flat while the sides approach each other ventrally. Though this is rather less marked in the buccal region, there is a distinct approach to the conformation (a three-sided pyramid) described by Smitt (Hist. Scand. Fish. ed. 2, p. 877) as characteristic of the head of the adult Capelin. The sides of the body are compressed and flattened, while the dorsum is also rather flat. *Mallotus* has the radial formula D. 12–16, A. 18–25; the vertebræ are from 65 to 70. In general proportions and in the relative position of the fins the oldest Iceland specimen is in agreement with *Mallotus* (compare Smitt's figures of the latter, *op. cit.* pl. xli. with my figure 11). The Iceland specimens are a good deal damaged and none have any scales on the body, but there are traces of them on the gill-cover of the largest. The teeth are small, and there is no distinct notch in the premaxillary region for the reception of the mandibular extremity.

Beyond a few remarks of Collett's, quoted by Smitt, I have not found any description of the young stages of *Mallotus*. Our

[1] Lütken ("Spol. Atlant., Changements de forme chez les Poissons," Vid. Selsk. Skr. 5. Række, 1880, p. 594) considers that pelvic fins probably exist in the young of all species of *Trichiurus*, though their presence is only indicated in the adult of one species.

Iceland forms show a certain resemblance to the genera *Paralepis* and *Sudis*. *Paralepis borealis* is known from Greenland, Iceland, and the North-American coast. Apart from other differences, the excessive number of anal rays and the large size of the teeth (*vide* Goode & Bean, Ocean. Ichth. p. 119, fig. 143) serve to separate it from the forms before us. *P. coregonoides* has occurred in the Mediterranean and on the American Atlantic coast, and may well exist in Boreal European waters. It appears to agree better than the last with the Iceland forms, but has the generic character of very large teeth. *P. sphyrænoides*, from the Mediterranean and Madeira, has 30 anal rays. I cannot ascertain the vertebral formula of any of these species. Under the name of *Sudis atlanticus* Smitt gives a brief account, derived from Kröyer, of a fish washed ashore at the Skaw. It had 20 anal rays, and so far as I can judge its young stage might bear some resemblance to the Iceland specimens. The balance of probability, however, appears to me to favour the association of the latter with *Mallotus villosus*[1], although, so far as I know, the Capelin has never been recorded from Iceland.

The smallest Iceland specimens bear a considerable resemblance to the largest of Dr. Fowler's larvæ. In the latter (fig. 8) the snout is obtuse and rounded except at the extremity. In the former (fig. 9) the snout is more pointed, but still somewhat rounded superiorly. A depression behind the eyes indicates the collapse of a sinus over the hind-brain, such as seems to have been also present in the Faeroe larvæ. The specimen 36 mm. long has the greatest height of the body only 2·5 mm.; the form being thus extremely elongate. The gradual increase in height is illustrated in figs. 10 and 11.

Most of the Iceland forms have only a few chromatophores scattered along the ventral surface, but one, about 42 mm., has a number rather widely diffused over the general surface of the head and body. How far the generally unpigmented condition is natural I cannot say.

A size-interval of 11·5 mm. separates the largest of the Faeroe larvæ from the smallest of the Iceland series. Since in the former the isolated spots of the ventrum appear to be in process of reduction, their absence in the latter is not necessarily a bar to the association of two series. The Faeroe larvæ have certainly a a smaller eye than the Iceland forms, but we have evidence of a developmental increase in the size of this organ in *Scopelus* which may well be repeated in other fishes of similar environment. In the Iceland series the proportions of the eye are variable; but in the larger and more perfect examples an increase is associated

[1] Dr. Günther considers that a number of larval forms, corresponding to Richardson's genus *Prymnothonus* (*vide* Chall. Rep., Zool. xxxi. Pelag. Fish. p. 39, pl. v.), "represent larval conditions of fishes belonging to *Paralepis* or *Sudis* or of genera allied to them." I venture to suggest that in the genera named the abdomen will be found to be much more elongate, from the earliest stages, than in *Prymnothonus*.

with advance of general development. In the number of myomeres both Faeroe and Iceland forms agree well enough with *Mallotus*.

The latter has not been recorded from any point nearer to the Faeroe Channel than the coast of Norway, but appears to be a fish of pelagic habit, approaching the coast only for the purpose of spawning. The ova are demersal, and it may be objected that our Faeroe larvæ are too young to be found so far from land. This objection depends for its validity on a knowledge of the rate of growth, which is not forthcoming.

Although I think I have demonstrated the possibility of connecting the Faeroe larvæ, through intermediate stages as represented by the Iceland series, with the adult form of *Mallotus villosus*, I do not think we are justified in considering the question settled. The fact is that we know next to nothing of the development of many marine forms and especially of the pelagic and bathybial species, nor can it be supposed likely that a few sporadic cruises have furnished us with an even approximately complete list of the fish-fauna of the Faeroe Channel. In all probability there is a strong resemblance between the larvæ of many physostomous fishes, however widely they may be separated in the adult condition. Of the method of reproduction of bathybial fishes, whether by pelagic or demersal ova, we are in most cases ignorant. The characters of the Faeroe larva, though probably sufficient to exclude it from the Murænidæ, are such as might occur equally in a Salmonoid, Scopeloid, or Clupeoid. Any Clupeoids known as inhabitants of the region may be eliminated, since we know the larval stages of all of them. The same remark applies, as I think, to *Argentina sphyræna*; specimens of 37 mm. have already acquired the adult conformation[1], though only about 13 mm. longer than the Faeroe example, which is still practically undifferentiated. The size-interval does not appear sufficient, and I imagine that this species of *Argentina* has a shorter larva, with, of course, fewer myomeres. *A. silus* has 65 to 68 vertebræ and is a much larger fish. It may conceivably pass through a larval stage like the Faeroe form if its pelvic fins undergo an anterior migration. Among the Scopeloids *Stomias* is an elongate form, and *S. ferox* has been recorded by Günther from the Faeroe Channel (Chall. xxxi. *op. cit.* p. 31).

However, the example in question, though capable of even specific determination, was again only 37 mm. in length; while I can find in the Faeroe larva of 24·5 mm. no trace of the barbel and enlarged teeth of *Stomias*. I have already referred to the characters of the *Paralepidæ*, and the enumeration might be prolonged but always without bringing us, for the present, any nearer to a definite conclusion.

Dr. Fowler's specimens were taken as follows:—

13 *i*. 60° 2′ N., 5° 49′ W. 100 to 0 fathoms. Two, 19 and 24·5 mm.

20 *c*. 60° 16′ N., 5° 49′ W. 400 to 300 fathoms. One, 17 mm.

[1] Holt & Calderwood, Trans. R. Dubl. Soc. ser. 2, v. 1895, p. 509, fig. J.

If they prove to be young *Mallotus* it will have been shown that form is capable of descending below the 300-fathom line. The localities are just outside the British area.

A Pelagic Egg, resembling Raffaele's species No. 7.

? Raffaele, Mittheil. zool. Stat. Neap. viii. 1888, p. 69, tav. 5. Undetermined species no. 7.

Dr. Fowler's collection contains only one egg, which is quite unlike any that has been recorded from British or Northern European coasts. Preserved in a weak solution of formaldehyde, it was not sufficiently transparent for an exact determination of the internal structure. It was therefore passed through the usual reagents into oil of cloves, a process which unfortunately involved a complete collapse of the zona radiata. An attempt to remove the latter without injury to the contents was only partially successful. The characters, as observed during the whole process of manipulation, appear to be as follow:—

The diameter is 3·5 mm., the shape approximately spherical. The zona is thin and probably without any distinctive feature, since some bubble-like markings present on one part appear to be due to the adherence of a thin layer of yolk-matter. The perivitelline space is certainly large, but the exact dimensions of the yolk had been obscured by rupture either in the net or by the action of formaldehyde. The embryo remains attached to a pyriform yolk-mass 1·19 mm. by ·90 mm., the narrow end underlying the head. The yolk is divided throughout into small rounded segments of irregular size, and appeared to possess, as seen in formaldehyde, a number of small oil-globules aggregated together. The embryo is advanced and has a considerable free tail, closely apposed to the yolk. Its total length may be estimated at about 2·40 mm. There appears to be no pigment. Any distinctive characters which may have been present could not be observed before the removal of the zona; and the specimen was too much injured in this process to admit of a reliable observation of the embryo.

Sufficient, however, has been noted to show that the egg agrees very closely, both in dimensions and other characters, with Raffaele's species no. 7. Grassi's researches[1] have confirmed Raffaele's suggestion of a Murænoid parentage for at least some of the group of evidently allied ova to which no. 7 belongs, one of them, no. 10, having been connected in a practically conclusive manner with the Common Eel (*Anguilla vulgaris*).

No observer has yet described the perfectly ripe egg of the Conger (*C. vulgaris*), nor has any attempt been made to identify with this abundant and rather valuable form any egg taken in the tow-net. It appears from Cunningham's description (Q. J. M. S. xl. p. 155) that the ripe egg probably differs from that of *Anguilla* in possessing one or more oil-globules, and therein agrees with Raffaele's sp. 7 and with the egg from the

[1] Q. J. M. S. xxxix. p. 371.

Faeroe Channel. In eggs characterized by a large perivitelline space, such as those of *Hippoglossoides* and some species of *Clupea*, the expansion of the zona is known to be accomplished after deposition. The difference of dimension of the yolk-mass, as between sp. 7, the Faeroe Channel egg, and the largest eggs obtained by Cunningham from the Conger[1], does not appear to be considerable. The specific identity of the three appears at least possible.

On the other hand, it may well be that Raffaele's group of eggs belongs in fact to more than one family of physostomous fishes. I have described from Dr. Fowler's collection a series of larvæ, which are apparently not Eels, but which in conformation and pigment agree rather closely with the larva of Raffaele's no. 7, though they entirely lack the peculiar buccal armature of the latter. Such armature is, in the Eels, a very temporary phenomenon, the leptocephaline condition being devoid of it.

To attempt to connect the Faeroe egg with the elongate larva from the same region were simply an unprofitable speculation; but it may be suggested that the characters of segmented yolk and large perivitelline space, common to Murænidæ and Clupeidæ, may be equally present in the ova of Scopeloids and of such, if any, Salmonoids as propagate by means of pelagic eggs. In point of attenuation I know no larvæ more eel-like than some of the Clupeoids. I do not suppose that the egg with which we are dealing is that of a Clupeoid, but, whether it be identical with Raffaele's no. 7, or different, our knowledge of the development of the pelagic and bathybial members of the other groups mentioned is hardly such as to permit us to definitely assign it to any one of them. *Mallotus*, which I have suggested as a possible parent of the elongate larva, is known to deposit ova which are demersal in littoral waters. If any description of their structure exists I have not seen it.

EXPLANATION OF THE PLATES.

Plate XLVI.

Fig. 1. *Scopelus glacialis*, 14·5 mm., p. 552. Formol.
2. „ „ 12 mm. Formol.
3. „ „ 11·5 mm. Formol. The larval sinus in front of the dorsal fin rather collapsed.
4. Dorsal view of the same specimen. Formol.
5. *S. glacialis*, 8 mm. Oil of cloves.

Plate XLVII.

Fig. 6. *S. glacialis*, 6·5 mm., p. 552. Oil of cloves.
7. „ „ 4·5 mm. Oil of cloves.
8. Larva with elongate abdomen, 24·5 mm., p. 560. Oil of cloves.
9. Head of young *Mallotus villosus*?, 36 mm., p. 560. From Iceland. Alcohol.
10. Young *M. villosus*?, 42·5 mm., p. 560. From Iceland. Alcohol.
11. „ „ 57 mm. From Iceland. Alcohol. Natural size.
12. Young *Gadus æglefinus*, 8 mm., p. 551. Formol.

[1] *Cf.* Journ. M. B. A., n. s. ii. 1891, pp. 24–25.